CABLE SYSTEM FOR DOWNHOLE USE AND METHOD OF PERFORATING A WELLBORE TUBULAR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation application of U.S. Ser. No. 16/497,546, filed 25 Sep. 2019, which is a national stage application of International application No. PCT/US2018/023788, filed 22 Mar. 2018, which claims priority benefit of U.S. provisional application No. 62/477,264, filed 27 Mar. 2017. International application No. PCT/US2018/023788 is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention is generally directed to a cable system for downhole use, and specifically to a magnetically detectable cable system. In one aspect, the invention is directed to a method of perforating a wellbore tubular provided with such a cable system.

BACKGROUND OF THE INVENTION

[0003] In the practice of operating oil and gas wells, it is not uncommon to deploy one or more cable systems alongside a casing. Such cable systems can include hydraulic cables, electrical cables, and/or fiber optic cables. Such cables may provide power and/or communication (p/c) capabilities between surface and downhole locations.

[0004] The use of, in particular, fiber optic (FO) sensors in downhole applications is increasing. In particular, optical fibers that can serve as distributed temperature sensors (DTS), distributed chemical sensors (DCS), or distributed acoustic sensors (DAS), and, if provided with Bragg gratings or the like, as discrete sensors capable of measuring various downhole parameters. In each case, light signals from a light source are transmitted into one end of the cable and are transmitted and through the cable. Signals that have passed through the cable are received at receiver and analyzed in microprocessor. The receiver may be at the same end of the cable as the light source, in which case the received signals have been reflected within the cable, or may be at the opposite end of the cable. In any case, the received signals contain information about the state of the cable along its length, which information can be processed to provide the afore-mentioned information about the environment in which the cable is located.

[0005] In cases where it is desired to obtain information about a borehole, an optical fiber must be positioned in the borehole. For example, it may be desirable to use DTS to assess the efficacy of individual perforations in the well. Because the optical fiber needs to be deployed along the length of the region of interest, which may be thousands of meters of borehole, it is practical to attach the cable to the outside of tubing that is placed in the hole. In many instances, the cable is attached to the outside of the casing, so that it is in close proximity within the borehole.

[0006] When a fiber optic cable system, or other type of cable system, is arranged on the outside of the casing, oriented perforating of casing may become important if the cable system is present at the level of the planned perforations. In some instances, a current practice for deployment of fiber optic sensor cables may entail the addition of one or more wire ropes that run parallel and adjacent to the fiber optic cable. Both the ropes and the cable may be secured to the outside of the tubing by clamps such as, for example clamps and protectors or with stainless steel bands and buckles and rigid centralizers. Such equipment is well known in the art and is available from, among others, Cannon Services Ltd. of Stafford, Tex. The wire ropes are preferably ferromagnetic (i.e. electromagnetically conductive), so that they can serve as markers for determining the azimuthal location of the optical fiber and subsequently orienting the perforating guns away from the fiber cable. These wire ropes may be on the order of 1 to 2 cm diameter so as to provide sufficient surface area and mass for the electromagnetic sensors to locate. Because of their size, the use of wire ropes can require costly "upsizing" of the wellbore in order to accommodate the added diameter. Besides necessitating a larger borehole, the wire ropes are susceptible to being pushed aside when run through tight spots or doglegs in the wellbore. Wire ropes that have been dislodged from their original position are less effective, both for locating the fiber optic cable and for protecting the optical cable from damage.

[0007] US-2015/0041117 and US-2016/0290835 disclose a system wherein an optical fiber is provided with two metal strips. The azimuthal location of the fiber optic cable system may be established from inside the casing by detecting magnetic flux signals. The strips can be detected by an electromagnetic metal detector from inside the well tubular to reveal the azimuthal location of the fiber optic cable. The metal strips can be made of an electrically conductive or ferromagnetic material such as steel, nickel, iron, cobalt, and alloys thereof.

[0008] However, such cable designs and installation configurations can require extensive mapping with a magnetic orienting tool (MOT), in order to achieve the required accuracy with respect to the location of the cable. The MOT, which is typically wireline run tool, may have to be stopped several times per joint of pipe for several pipe joints to locate the cable and build a cable location map with sufficient reliability.

[0009] Hence it is desirable to provide an improved system and method for magnetically determining the azimuthal position of a cable, for example a cable comprising an optical fiber, deployed on the outside of a tubular. Such improved system may need fewer measurement locations and/or determine the azimuth of the cable location with less uncertainty.

SUMMARY OF THE INVENTION

[0010] In one aspect, the present invention provides a cable system for downhole use, comprising cable and a magnetic-permeability element configured along a length of the cable, said magnetic-permeability element comprising a material having a relative magnetic permeability μ_r of at least 2,000.

[0011] In operation, the cable and the magnetic-permeability element are arranged on one side of a metal wall, whereby the cable and the magnetic-permeability element can be located using a magnetic orienting tool on the other side of the wall. The magnetic orienting tool senses the the magnetic-permeability element through the metal wall.

[0012] In another aspect, the invention provides a method of perforating a wellbore tubular provided with a cable system for downhole use, comprising: